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south and perhaps to the north by Eocene Tertiary beds, and the appearance of the country indicates that a smaller lapse of time has separated the periods of their deposit than is usual. Nevertheless no traces of Cretaceous types of vertebrates have yet been found in any of these Tertiaries.

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## EFFECTS OF EXTRAORDINARY SEASONS ON THE DISTRIBUTION OF ANIMALS AND PLANTS.

BY PROF. N. S. SHALER.

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WHATEVER throws any light upon the nature of the means whereby the changes in the character and distribution of organic forms have been effected, has for the student of geology the keenest interest. I therefore venture to call attention to the peculiar effects of the last year upon the forests and probably upon some of the animals of New England. The year preceding the winter of 1871-2 was one of the driest on record in this region; the rainfall was not only much less than usual, but came in such a fashion as to leave the ground very dry when winter came. The snowfall during the winter was slight and did not lie well upon the ground, melting and drifting in such fashion as to leave a large part of the surface quite unprotected. In this state the long continued and steady cold froze the earth to a great depth, and at some points the frozen ground was found as far as five feet from the surface. Over the whole of New England it was doubtless deep enough to involve the whole of the roots of the vegetation of our forests. It is doubtful whether it was the intensity of the cold alone which produced the effects which have been observed all about us, but more likely that it was in large part due to the deficiency of sap in the plants, in connection with the low temperature; as the frost left the roots, they remained for some time in contact with relatively dry earth, thus causing a shock too great for their vitality to withstand. I do not see clearly just how the cold and drought coöperated in bringing about this destruction, though I have no doubt they worked together.

The tree which suffered most is the arbor-vitæ (*Thuja occidentalis*) for more than half of these are dead and a large part of those

yet alive are in a critical condition. The red cedar (*Juniperus Virginiana*) is also a great sufferer in some regions, most of the specimens being dead or dying, while in others the greater part are unhurt. The yellow and white pines (*P. mitis* and *P. strobus*) are also much injured in many places, though in most cases immediate death has not resulted. All the other coniferous trees about Massachusetts Bay have suffered more or less. The greatest amount of damage seems to have taken place in sandy soils. So far as I have been able to observe, the trees placed so as to receive the greatest amount of moisture have on the whole withstood the crisis the best. The deciduous trees appear to have come out without damage; I have not yet been able to find any evidence of unusual loss among them. The same may be said for our herbaceous plants which, so far as my limited knowledge goes, show no signs of damage.

The only change in animal life which I have noticed is the comparative scarcity of snakes. In about two hundred miles of walking in the fields and woods I have encountered but three; of course, in a matter where it is so difficult to be sure of comparative numbers in different seasons, it will not do to make positive assertions, but I am strongly inclined to believe that the same amount of walking would have shown me several times as many snakes in former years. I am sure that this is the first year that I have gone until July spending at least one day in the week in the open air, without seeing a black snake. Toads seem to me also much less common than usual.

The most interesting point in this connection is the question as to what would have been the effect of carrying this accident of climate a little further. Small as the destruction of forest trees is, it will doubtless add several per cent. to the deciduous trees of New England, and remove an equal amount of conifers. The conifers seem to be relics of an old time and not competent to wage a successful war with their younger and more elastic competitors, the oaks, beeches and other deciduous trees. Every gap that is made in our forests of cone-bearing species is filled not with their legitimate successors, but by forms from the other class of trees. Let us suppose that the shock of the last season had been great enough to kill off the whole of our pines, the result would have been a complete change in the character of our forests; oaks generally would take the vacant place. This would

affect the character of the undergrowth very materially, for the lesser plants of a pine wood are very different from those which flourish beneath oaks. This would have had a very great effect upon insect life, and more or less directly influenced the number and character of the birds and the mammals. Even the climate would be in some small measure influenced, for a pine forest retains the snow better than one which loses its leaves in the winter and thus tends to secure a more equable temperature in the region where it lies.

Thus we see that an accidental drought might bring about a change in the assemblage of vital conditions on the surface of the land, as great as those which, when recorded in strata, we accept as indicating distinct geological formations.

It may not be amiss in passing, to call attention to the fact that the rate of change in land life, as far as change depends upon variations of temperature, must be far greater than in the sea. The sea knows no such frequent accidents of heat, cold and moisture as are at work on the land.\* The difference in these conditions is well measured by the range of migration of species. Our Liquidambars, Liriodendrons, and other forest trees of the Mississippi Valley have, during the later stages of the Tertiary period, ranged as far as Greenland, or through over forty degrees of latitude. The greatest range of marine forms, as far as I am aware, is not more than one-third this amount in the same limits of time.

It is very desirable that abundant observations on the influence of the last winter on animal and vegetable life should be put on record. The author of these remarks would be glad to hear communications on this subject. Any information of importance will be printed in this journal with the proper acknowledgments.

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\* In one way marine accidents may produce great changes of temperature in the sea. This is readily conceived by the following example. The destruction of Cape Cod would lower the average summer temperature of the region about Vineyard Sound by twenty degrees or so. The result would be the expulsion from that region of at least one-fifth of the marine forms now found there.